

C-17 COEA Case Study

for Presentation to IDA Modeling & Simulation Working Group



Bill Greer

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Abstract This report is part of a series of papers written to describe influential studies completed by the Institute for Defense Analyses (IDA) that may prove useful to others who must either conduct analyses or review analyses in support of major acquisition decisions. This particular report is a case study of the analyses and circumstances informing the decisions made in 1993-95 regarding the C-17 strategic airlifter program. It includes a discussion of the events leading to the study, the analytical approach taken, the study participants, critical points in the analyses and in the program, decisions reached after the study was completed, and lessons learned.		
Subject Terms C-17; strategic airlift; C-141 SLEP; C-5; C-130; analysis of alternatives; AoA; cost and operational effectiveness analysis; COEA; utilization rate; maximum on ground; MOG; major theater war; MTW; cargo transportation requirements; CRAF; outsize cargo; KC-10; FMTV; militarized 747		
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Basic Premise

- **Part of a Series of Papers on Completed Studies**
- **To Aid Future Analysts and Those Advising Decision-Makers on Utility of Analyses**

C-17 Background

- **In 1992 The USAF Program to Buy 120 C-17 Aircraft Was in Trouble**
 - **High C-17 Cost Growth**
 - **C-17 Wing Failures in Static Tests**
 - **Overheating in Wing Flap Trailing Edges**
 - **Could not Meet Payload/Range Specs: 80 tons at 2,400 nmi**
- **Lockheed Proposed Extending Service Life of C-141s in lieu of Buying C-17s**
- **Congress Restricted DoD from Spending FY94 Funds until Report Was Provided on Cost, Operational Requirements, and Comparisons of Alternative Airlifters**
- **IDA: To Provide Comparative Cost & Operational Assessments of C-17 & Alternative Airlift Fleets**

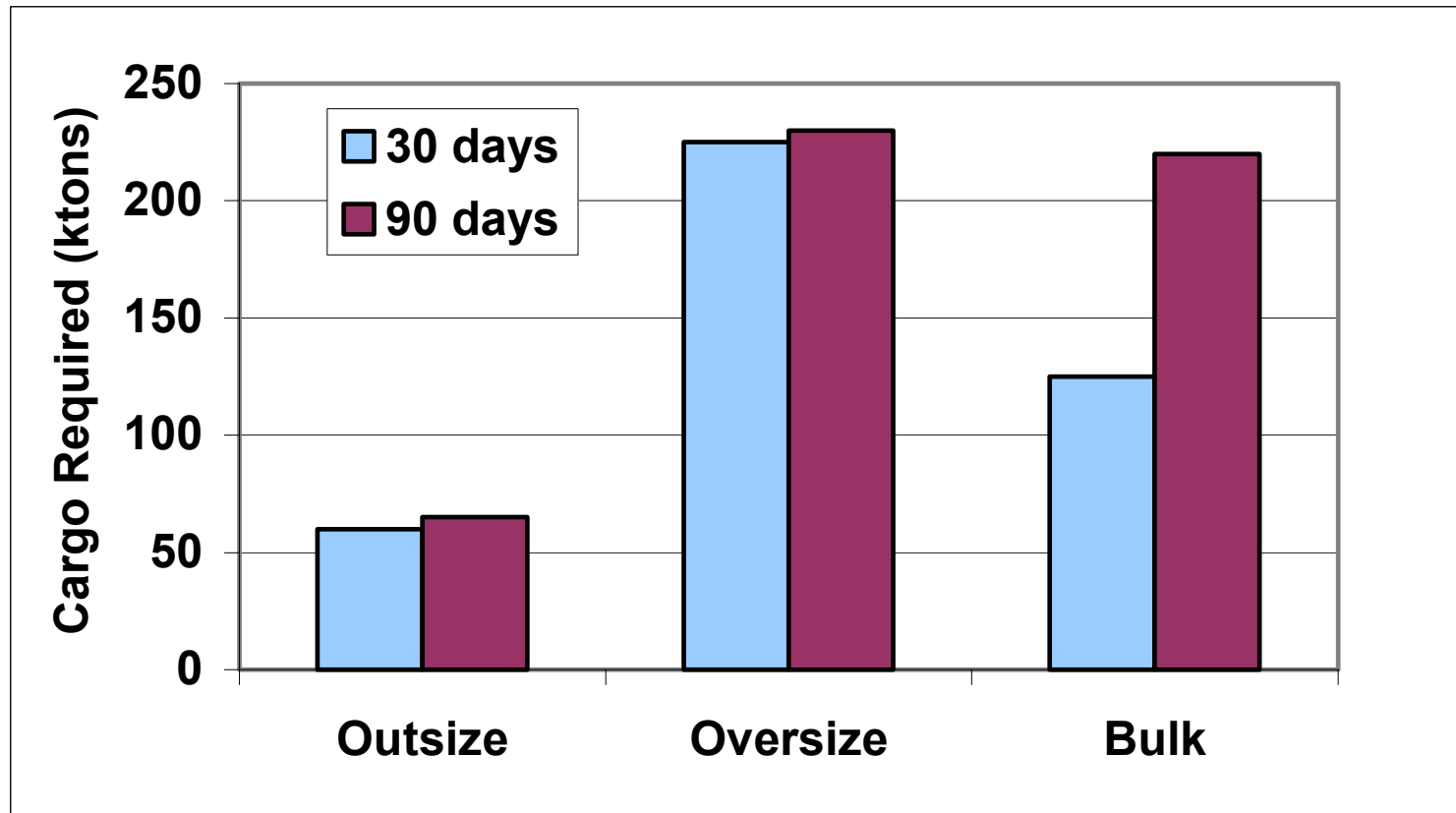
Organizations

- **OSD**
 - Tasked IDA to Perform COEA
 - Provided Requirements (TPFDD)
- **Air Mobility Command**
 - Provided Operational Data
 - Ran Operational Effectiveness Model
- **Air Force Studies & Analysis Agency**
 - Conducted Shadow Studies
- **Joint Staff**
 - Conducted Shadow Studies
- **USAF Program Offices and Industry**
 - Provided Cost Estimates

Overall Methodology

- **Establish Airlift Requirements**
 - Dual Major Regional Contingencies (MRC)
 - Lesser Regional Contingencies (LRC)
- **Identify Fleet Alternatives**
 - Sized to Deliver Same Tonnage under Optimistic Conditions
- **Estimate Fleet Costs**
 - Acquisition, Operating & Support
- **Estimate Fleet Effectiveness**
 - Model Fleet Movement of Cargo through Theater Airfields
- **Show Cost and Effectiveness Results**

MRS Airlift Delivery Requirements for MRC-East and MRC-West Combined



Note that Outsize and Oversize Cargo Delivery Requirements are the Most Time-Critical.

Airlift Aircraft Considered

- **Military Airlifters (Owned & Operated by USAF)**
 - **C-17**
 - **C-141**
 - **Service Life Extension of Current C-141**
 - **Replacement C-X at end of C-141 Service Life**
 - **C-5B+**
 - **New Noise/Pollution Compliant Version of C-5B**
 - **Militarized Commercial Derivative Airlifters**
 - **747**
 - **767**
 - **C-130**
- **Civil Reserve Airlift Fleet (CRAF)**
 - **Commercial Aircraft Called into Service During Emergencies**

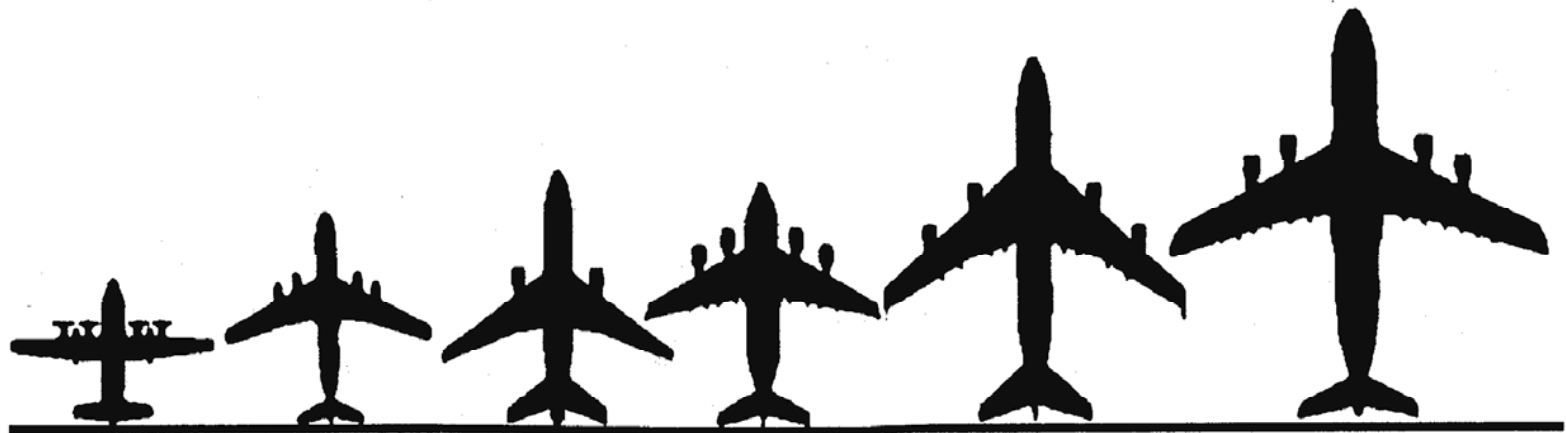
CRAF Call-Up Stages

- **Stage I—Commander, Air Mobility Command, activates a pre-set number of commercial aircraft on 24-hour notice**
 - **Used in 1990 to support Operation Desert Shield deployments to Southwest Asia**

- **Stage II—Secretary of Defense (SecDef) activates additional aircraft for more serious emergencies**
 - **Only used once, for Operation Desert Storm**

- **Stage III—SecDef authorizes more aircraft, but only after the President or Congress declares a national emergency**
 - **Never been used yet**

Aircraft Size and Capacity Comparisons



	C-130	C-141B	KC-10	C-17	747	C-5
	Bulk	Bulk Oversize	Bulk Some Oversize	Bulk Oversize Outsize	Bulk Some Oversize	Bulk Oversize Outsize
MAX PAYLOAD (Lb)	41,220	89,000	166,000	169,000	243,000	239,000

Utilization Rates

Airlifter Category	Airlifter Type	Surge Use Rate (Hrs/Day/PAA)
Military	C-5A/B	11.0 (average)
	C-141 SLEP	12.5
	C-17	15.2
	C-5B+	12.5
	KC-10	12.5
Commercial Derivative	Militarized 747 or 767	12.5
CRAF	All	10.0

Alternatives with 52 Million Ton-Miles per Day (MTM/D)

MTM/D = (Number available aircraft)x(use rate in hrs/day)x(single aircraft payload in tons)x
(block speed in kts)x0.47/1,000,000

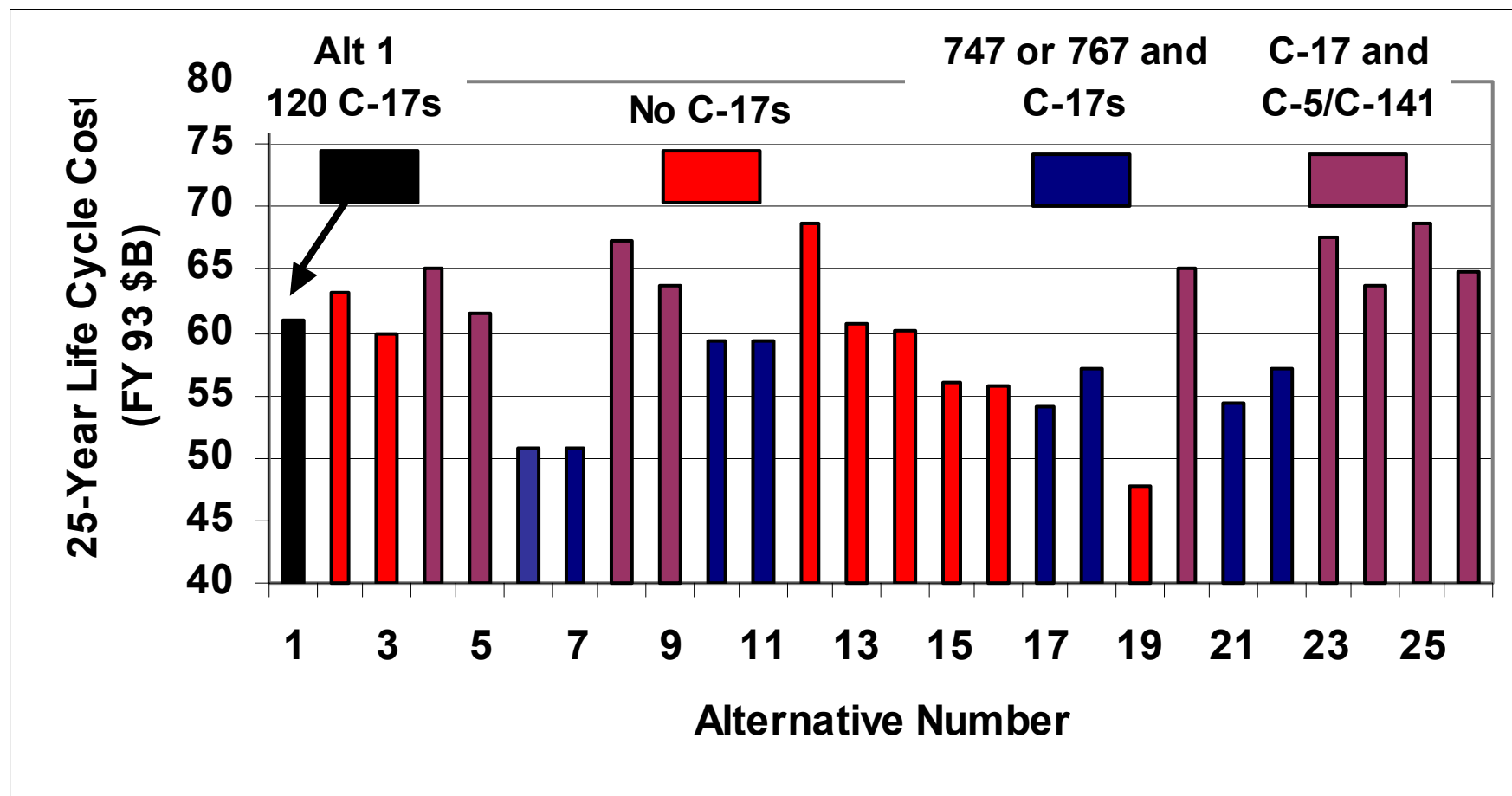
Categories	Alternative Number	Numbers of Aircraft in Fleet				
		C-17	C-141 SLEP	C-5B+	747	767
One New Aircraft	1	120				
	2		263			
	3			102		
Two New Aircraft, No C-17s	12		136	49		
	13		136		40	
	14		136			65
	15			49	42	
	16			49		69
	19				32	83

All alternatives include 37 MTM/D from a core fleet of 109 C-5A/Bs, 23 KC-10s, and Stage III CRAF.

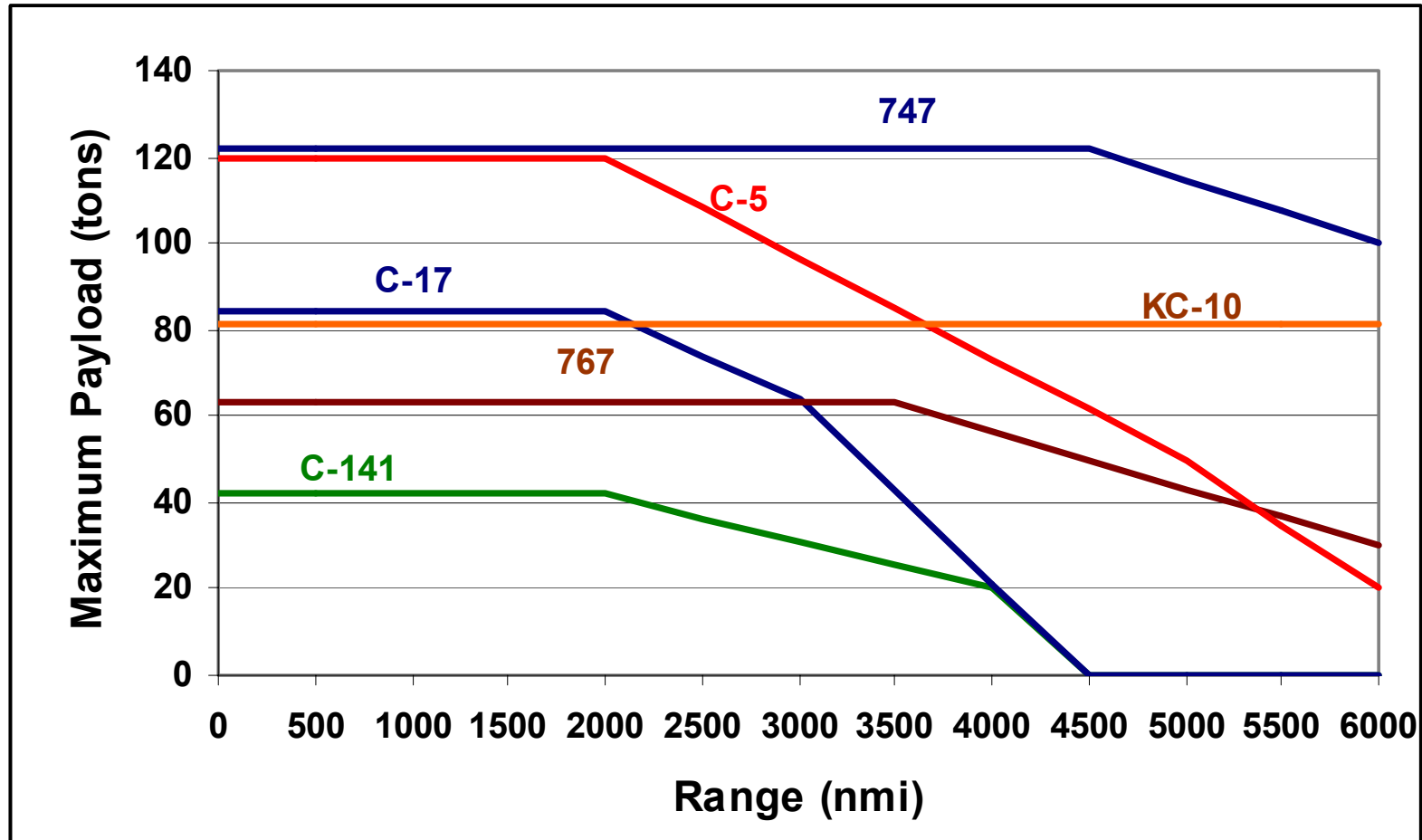
Alternatives with 52 MTM/D (Cont'd)

Categories	Alternative Number	Numbers of Aircraft in Fleet				
		C-17	C-141 SLEP	C-5B+	747	767
Two New Aircraft, including Reduced Buy of C-17s	8	94	58			
	9	94		21		
	10	94			18	
	11	94				30
	25	70	108			
	26	70		42		
	18	70			34	
	22	70				56
	23	47	160			
	24	47		62		
	21	47			49	
	17	47				83
	4	26	212			
	5	26		82		
	6	26			66	
	7	26				108

Summary of Fleet 25-Year Costs



Range/Payload Curves



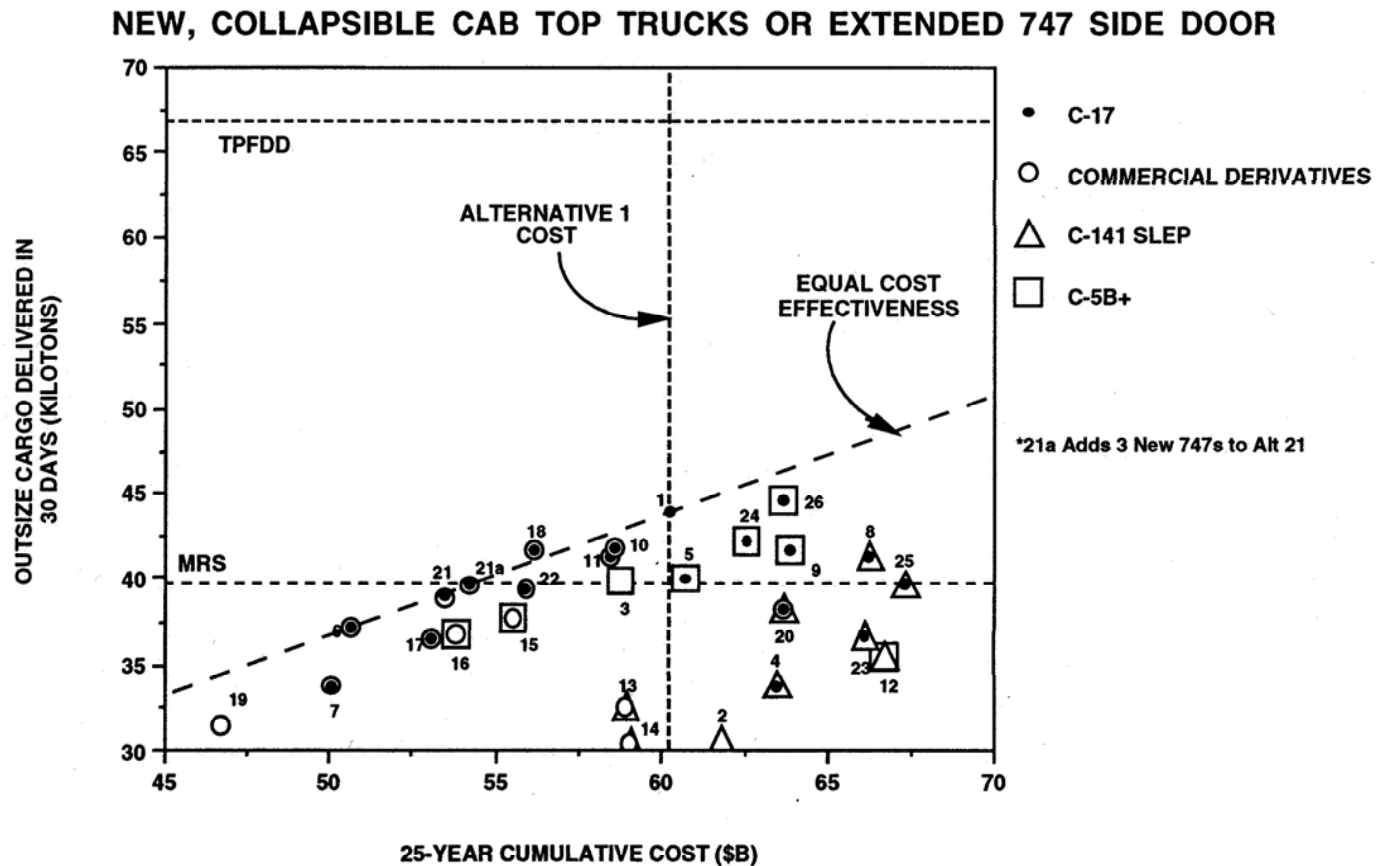
MOG Estimates

	Maximum Number of Aircraft on Ground Simultaneously (by Theater and Aircraft Type)		
MRC Theater	C-17	C-141 SLEP, 767	C-5, KC-10, 747
East	26	26	15
West	24	20	11

The Army Truck Problem

- **Army Plans to Replace Current Trucks with Family of Medium Tactical Vehicles (FMTV)**
- **Future Army Trucks Differ from Current ones in the Following Significant Ways**
 - **Non-collapsible Cab Tops (Chem/Bio Protection)**
 - **Higher Axle Loads**
- **These Features Make it Very Difficult for 747 or 767 to Load & Transport Army Trucks Unless Fuselage Modifications Are Introduced**
 - **Wider Side Door**
 - **Stronger Reinforcements on Floor**
- **Even with Such Mods, Payloads Will be Smaller for FMTV than for Current Trucks**

Comparison of Cost and Effectiveness of Alternatives with FMTV



Findings

- **The planned C-17 Cost and Performance Makes It the Preferred Military Airlifter**
 - C-17 Is More Resistant to Airfield Constraints Than C-5
 - C-17 Possesses a Higher Use Rate
 - C-17 Is Far Superior in Both Cost and Effectiveness to the C-141 SLEP
- **The Most Attractive Alternatives to the 120 C-17s Would Be Mixes of C-17s and Commercial Derivatives**
 - With Specially Reinforced Floors
 - and Wider Side Doors for New FMTV Army Trucks.
- **If New Army Trucks Cannot Be Loaded on Commercial Derivatives**
 - Next Most Attractive Alternatives to the 120 C-17 Program Would Be Mixes of C-17s and New C-5s

Impact & Subsequent C-17 Decisions

- **January 1994: Decisions Made by Defense Acquisition Board (DAB) to**
 - Cap C-17 Acquisition at 40 Aircraft (Out of 120 Planned)
 - Initiate a Program on Competitive Militarized Commercial Airlifters
- **Non-Developmental Airlift Aircraft (NDAA) Program Was Initiated to Solicit Offers From Industry**
 - Boeing Proposed 747
- **Air Mobility Command Conducted Strategic Airlift Force Mix Analysis (SAFMA) in 1995**
 - Pointed Out Pros and Cons of 747s vice C-17s, Favoring C-17s for Military Missions
 - IDA Critiqued the SAFMA Methodology for OSD
- **Meanwhile, C-17 Improved With Competition**
 - Wing Beefed Up, Performance Improved
 - Cost Reduced
- **November 1995: DAB Decided in Favor of C-17**

Questions for Discussion

- **Cost**
 - What category of cost makes the largest contribution? How does the time period chosen influence this?
 - The IDA study used 25-year costs, discounted to FY 1993 value. In what other reasonable ways might costing be conducted? How would they influence the study results?
 - Do you have any recommendations on how costs for aircraft with different values in 25 years should be treated?
- **Effectiveness**
 - The IDA study used Outsize cargo delivered in a 30-day period as the main measure of effectiveness. What other measures might be reasonable and can you guess the general impact – if any – on the results?
 - The study included some excursions to test the influence of modeling assumptions. What were the key modeling assumptions? How would altering them influence the results?
- **Other**
 - The study involved cooperation, but it also featured rivalries, both in the conduct of the study and in the competition introduced in the favored alternatives. Comment on the role these rivalries played.

Lessons Learned

- **Importance of Open Process**
- **Value of Competition**
- **Significance of Inputs**
 - **Army Trucks Would Have Trouble Fitting in 747s**
 - **Importance of MOG**
- **Costs**
 - **Differences of Opinion Over Acquisition Costs Not Crucial in Decisions, Although Ultimately Are Important for Budget Purposes**

Backup Slides

Summary of O&S Costs

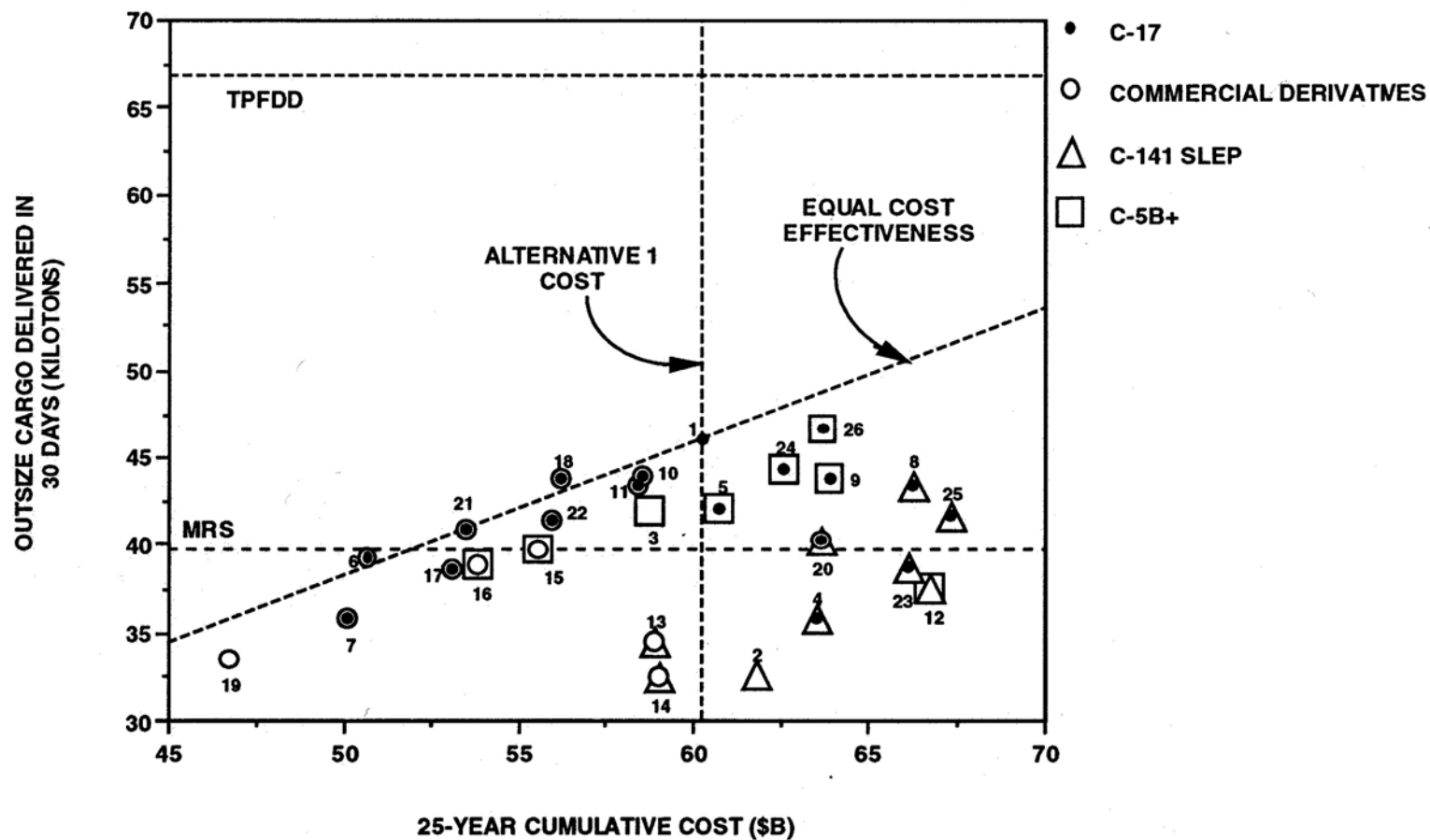
Aircraft	Number Flying Hours/Year	O&S Cost (\$M/year/PAA)
C-17	1,427	10.8
C-5B or B+	660	9.49
C-5A	325	6.75
C-141 SLEP	1,178	7.72
747	900	8.08
767	900	4.98
KC-10A	550	4.62
C-130E/H	637	4.01

USAF Core Model Results

Operational Issues & Excursions

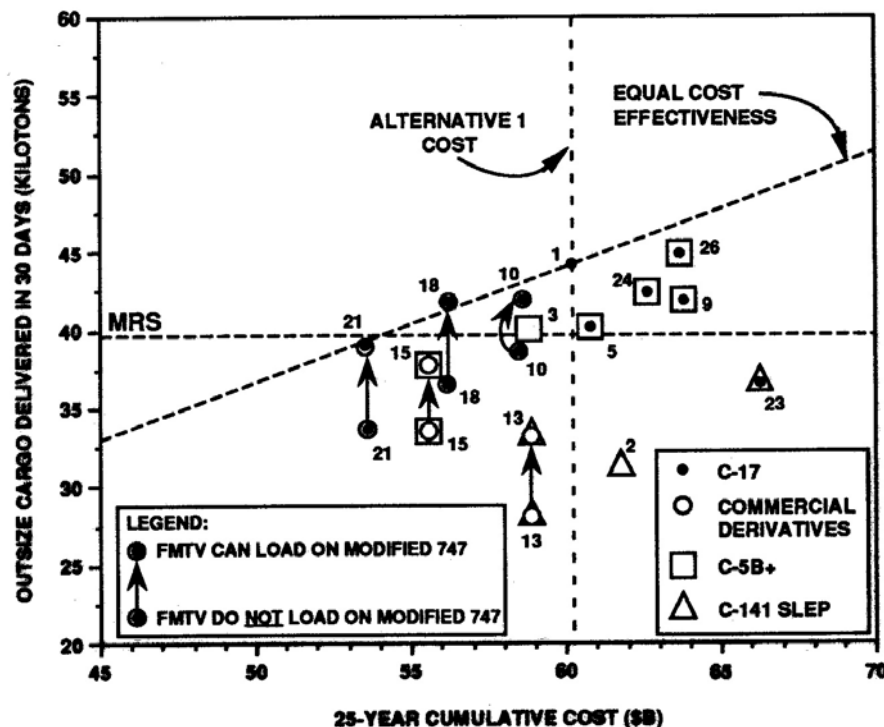
- **What if the New Trucks Cannot be Loaded onto 747s?**
 - **Widening Doors on Side might Introduce Undesired Aero Loading Problems**
 - **Loading Large Heavy items from a 60k Material Handling Equipment (MHE) May Prove Operationally Difficult or Dangerous**
- **What if the MOG Conditions are Worse than Analyzed?**
 - **MOG space at Airfields is Shared among all Aircraft Operating from that Base**
 - **Low Airlift MOG was the Experience in Desert Shield/Desert Storm**
- **What if C-17 Fails to Attain High Use Rates?**
 - **15.2 Hrs/day Exceeds Experience with Military Airlifters**
- **What if More Than 52 MTM/D is Desired?**
- **How Do Results Look for a Lesser Regional Contingency?**

Comparison of Cost and Effectiveness of Alternatives with Current Trucks

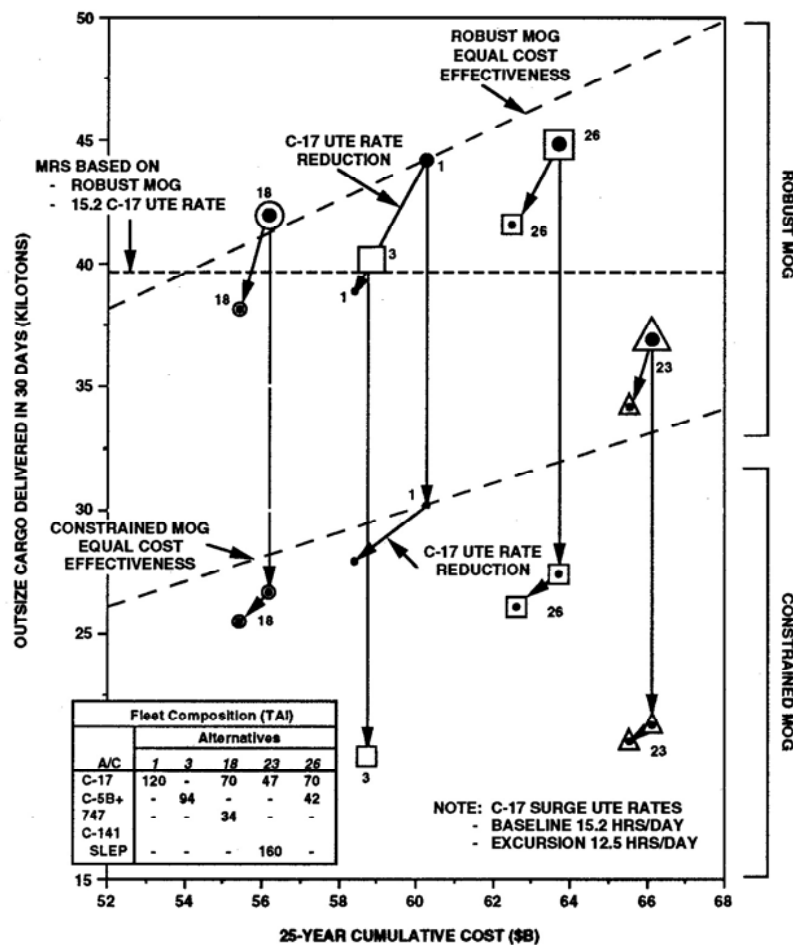


Comparison of Selected Alternatives with Different Assumptions about FMTV Loading on Militarized 747

A/C	Fleet Composition (TA)														
	Alternatives														
	1	2	3	5	9	10	13	15	18	21	23	24	26	70	
C-17	120	-	-	26	94	94	-	-	70	47	47	47	70		
C-5B+	-	-	94	82	21	-	-	49	-	-	-	62	42		
747	-	-	-	-	-	18	40	42	34	49	-	-	-		
C-141	-	-	-	-	-	-	-	-	-	-	-	-	-		
SLEP	-	263	-	-	-	-	136	-	-	-	160	-	-		

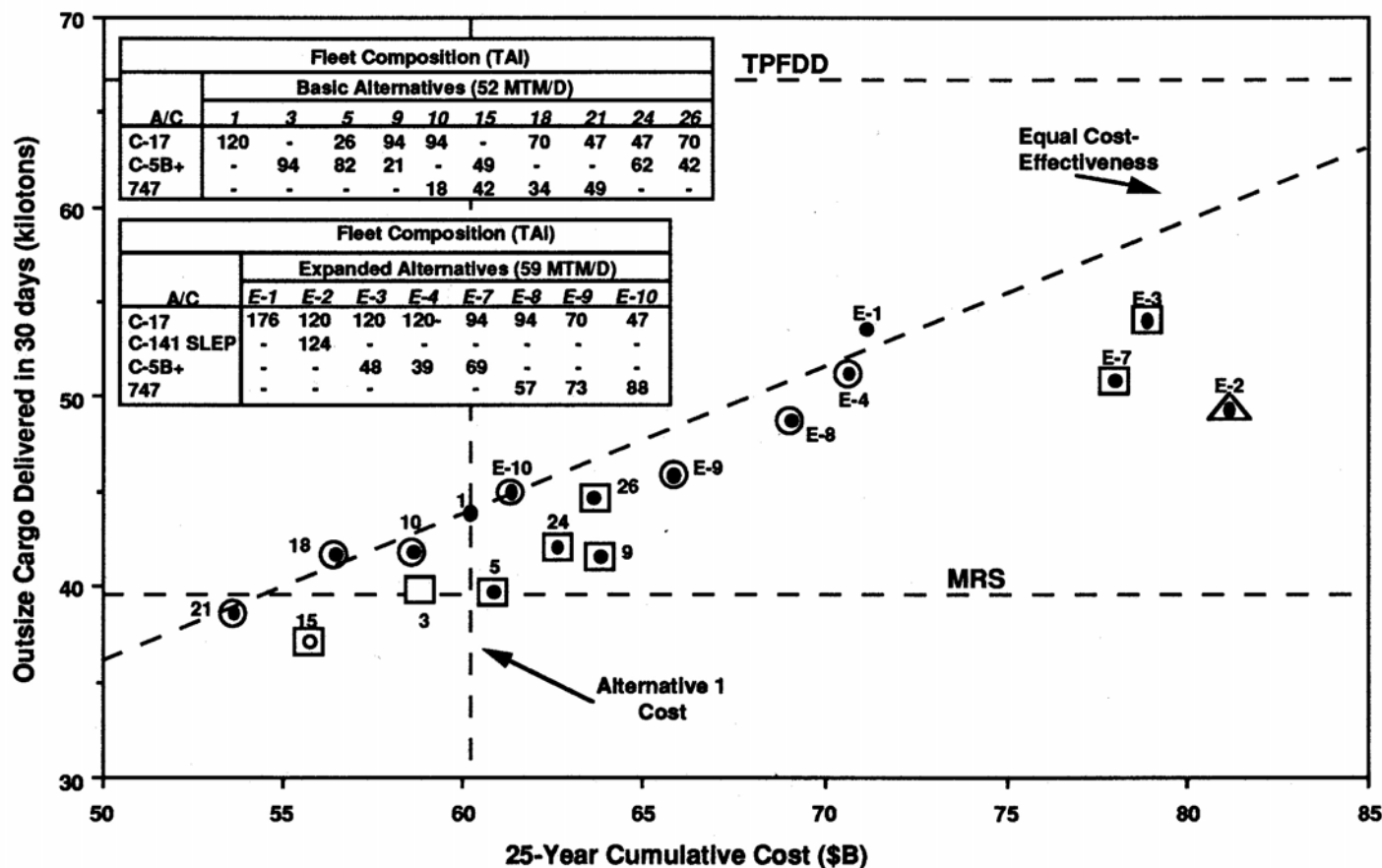


Impact of Reduced MOG and Reduced C-17 Use Rates



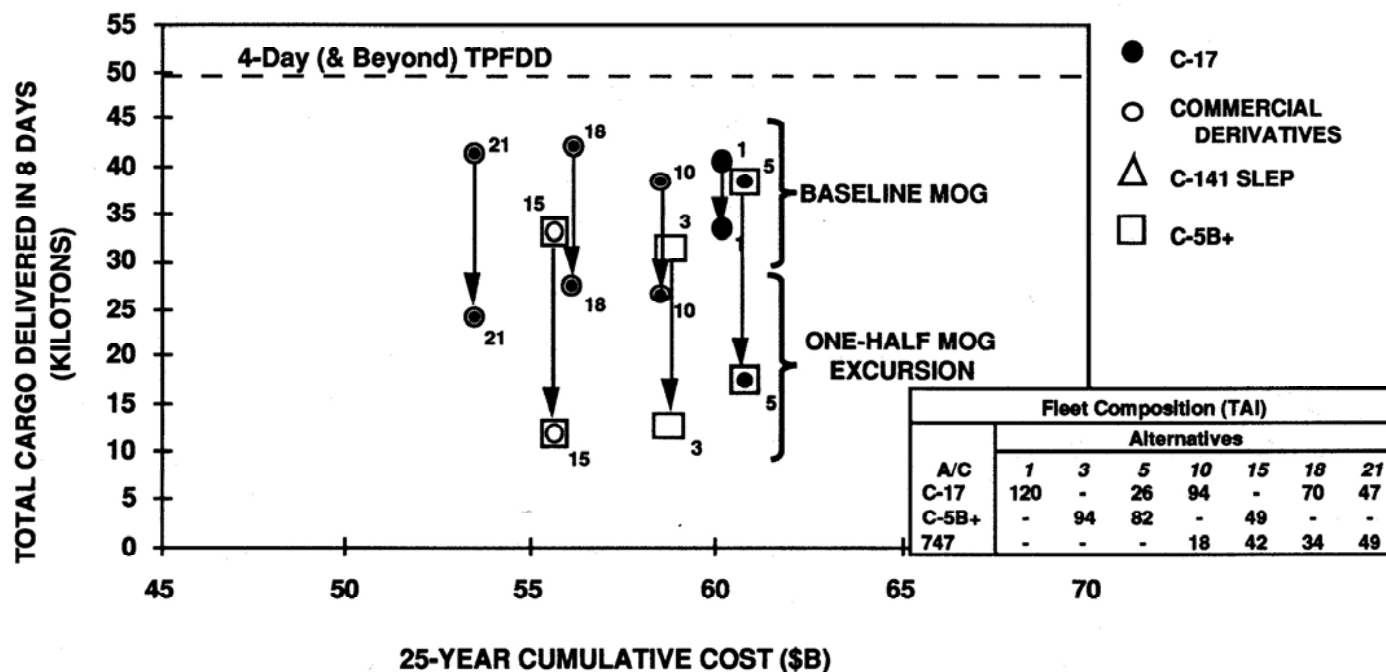
Comparison of 59 MTM/D Expanded Capacity Alternatives with the Nominal 52 MTM/D Alternatives

NEW, COLLAPSIBLE CAB TOP TRUCKS OR EXTENDED 747 SIDE DOOR



Comparisons of Alternatives in LRC-Short

NEW COLLAPSIBLE CAB TOP TRUCKS OR EXTENDED 747 SIDE DOOR



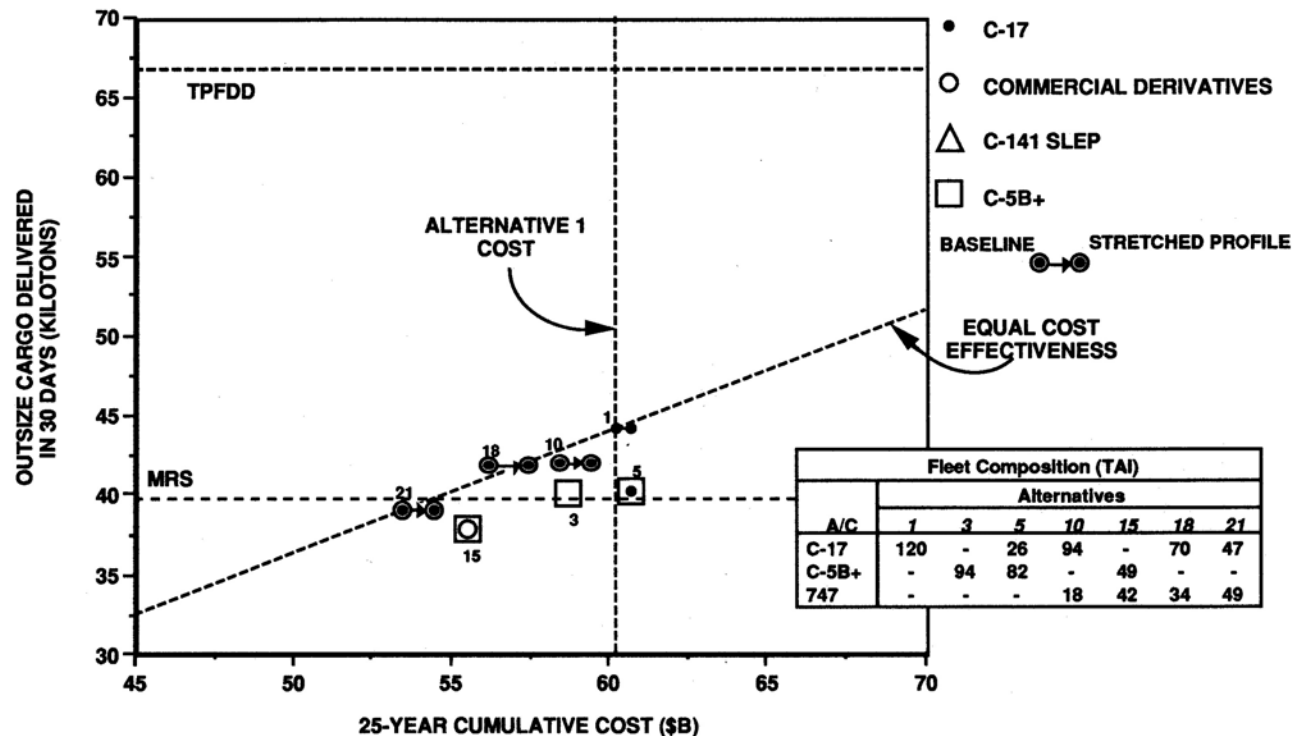
Cost Issues & Excursions

- **What if Costs for Alternatives are Bounded during next 6 years by the FYDP Acquisition Projections?**
 - **Baseline Cost Analyses Involve Realistic Production Levels, but Were not Constrained by Cost Caps Each Year**

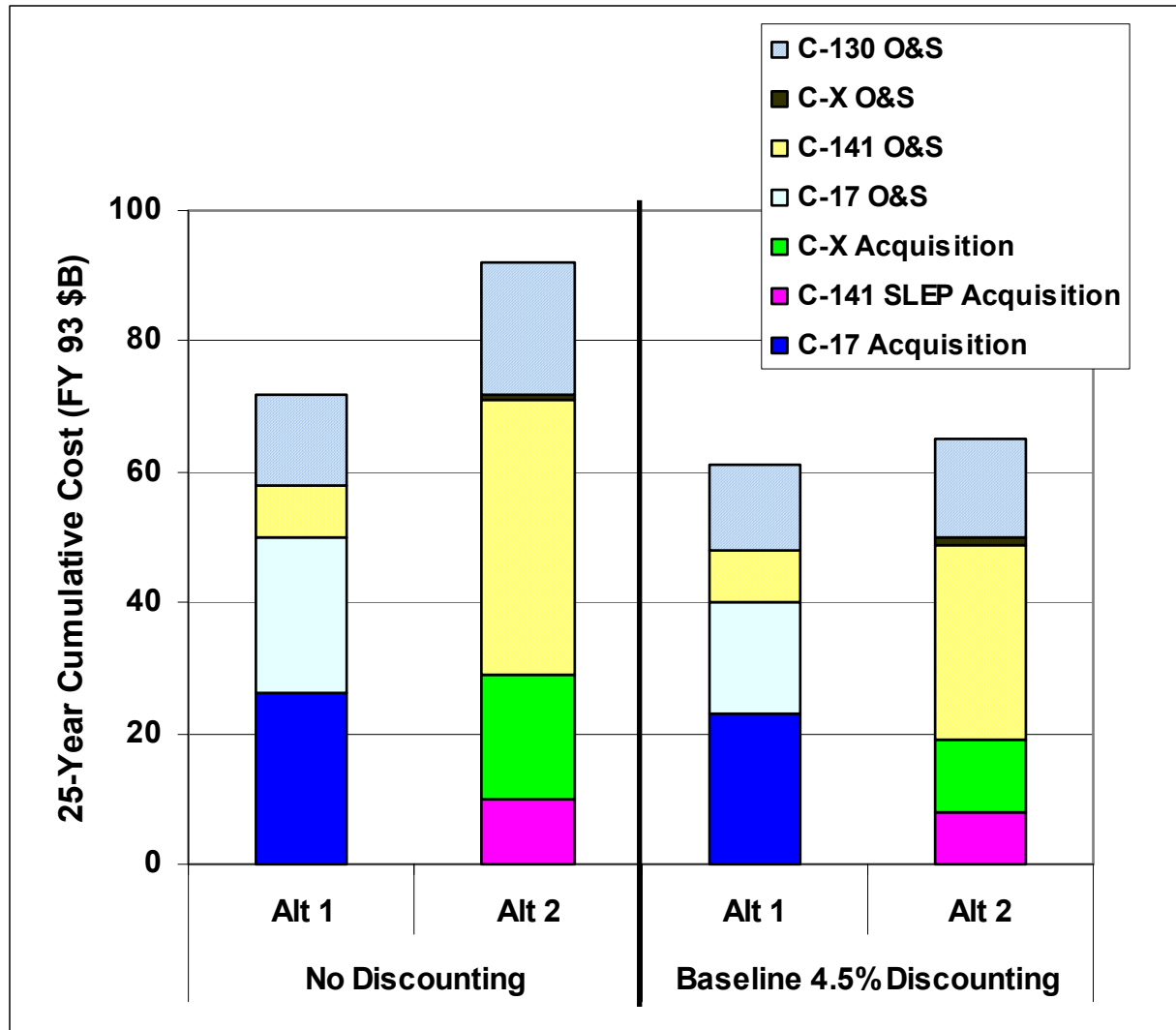
- **How Do non-Discounted Costs Look?**
 - **OMD Directs that Discounting be Included in Cost-Effectiveness Comparisons**
 - **Baseline Estimates include 4.5% discount factor, per guidance from OMB Circular A-94 (updated annually)**
 - **But USAF Often Uses non-Discounted Costs**

. Impact of FYDP Stretch-Out on Alternatives in MRC

NEW, COLLAPSIBLE CAB TOP TRUCKS OR EXTENDED 747 SIDE DOOR



Discounting & No Discounting Cost Comparisons



GAO Comments & Recommendations

- **Use Rates**
 - C-17 use rates were too high in IDA Study
 - Rates of the commercial derivatives were too low
 - (Subsequent tests have shown that the C-17 rates used were correct, although IDA did include excursions with the lower rates).
- **C-130s**
 - IDA should not have included fewer numbers of C-130s in the C-17 alternatives
 - This assumption gives the C-17s extra cost benefits by lowering the O&S costs associated with a smaller C-130 fleet
 - The GAO felt that no C-17s would be used in tactical roles and therefore no cost reductions associated with requiring fewer C-130s should be claimed.
 - (C-17s have subsequently been used in both strategic and tactical missions in Kosovo. Moreover, including the O&S cost for more C-130s influences the results by less than 1 percent, so is unimportant to the bigger issue).
- **MOG Assumptions**
 - DoD should use the robust MOG cases instead of moderate or constrained cases
- **Acquire 40 C-17s and 64 of the 747s instead of the 120 C-17s**